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| *Title:* | **AHG7: Chroma coding structure/tools in HEVC fidelity range extension** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Kei Kawamura Tomonobu Yoshino Sei Naito  2-1-15, Ohara, Fujimino-shi, Saitama, JAPAN | Tel: Email: | +81 49 278 7411 ki-kawamura@kddi.com |
| *Source:* | KDDI Corp. (KDDI R&D Laboratories, Inc.) | | |

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# Abstract

This contribution proposes the consistent coding structure and tools for all planes. Since 4:4:4 chroma format has the same resolution for all planes, some limitations can be relaxed. Furthermore, different structure and prediction mode between each plane cause the visual artifact in RGB 4:4:4 format.

# Introduction

This contribution proposes to utilize the same structures and tools for all planes in HEVC fidelity range extension (FrExt). For instance, RGB444 chroma format has the same resolute and the same visual significance for all planes. Therefore it is reasonable that all planes use the same coding structure, prediction mode, and tools.

# Problem statement and proposed structure/tools

## Problem statement

In 4:4:4 chroma format, non-main plane like Cb/Cr and B/R have the same resolution as main plane like Y and G. Some coding structure, prediction mode, and tools are however different between main and non-main plane. In the following, three categories are described.

In 4:2:0 chroma format, coding structure of non-main plane is different from that of main plane. For example, PART\_NxN indicate that luma has four prediction modes but chroma has only one prediction mode. For other example, restriction of minimum TU size causes the difference of TU depth between luma and chroma.

Regarding quantization, chroma QP clipping function is introduced for YUV color space. For RGB color space, since all planes have generally equaled visual significance, QP clipping is not needed.

Chroma intra prediction can select different prediction mode from luma prediction mode. For RGB color space, different prediction sometimes causes a visual artifact due to the RGB display. Since signal in YUV color space are transformed to that in RGB space of display, such artifact is suppressed.

Although it is implementation issue, current HEVC test-model decides coding structure and prediction mode based on only luma component in intra frame.

## Coding structure

We proposed to allow use of the PART\_NxN for non-main planes. This modification enables all PUs to have the same intra prediction mode.

## Coding mode

For RGB color space, we propose to always use the same prediction mode for all planes. Consequently, no chroma intra-mode coding is necessary.

## Coding tools

We proposed to apply some existing intra-smoothing-tools to all planes. On the other hand, after signal processing, we propose to independently use an entropy coding tool like significance map.

# Implementation

The proposed scheme is realized by change the following macro in TypeDef.h.

#define ECF\_\_COMBINED\_LUMA\_CHROMA\_INTRA\_MODE\_SEARCH 1

#define ECF\_\_REDUCED\_CHROMA\_INTRA\_MODE\_SET 1

#define ECF\_\_ADDITIONAL\_TRIAL\_ENCODE\_CHROMA\_INTRA\_MODE\_SEARCH 0

#define ECF\_\_INTRA\_NxN\_CU\_CHROMA\_PU\_SPLIT\_MODE 1

#define ECF\_\_ENCODER\_FULL\_RATE\_DISTORTION\_SEARCH\_OVER\_ALL\_COMPONENTS 1

#define ECF\_\_CHROMA\_INTRA\_REFERENCE\_SAMPLE\_FILTERING 1

#define ECF\_\_SET\_INTRA\_CHROMA\_EDGE\_FILTER\_422 1

#define ECF\_\_SET\_INTRA\_CHROMA\_DC\_FILTER\_422 1

#define ECF\_\_SET\_INTRA\_CHROMA\_EDGE\_FILTER\_444 1

#define ECF\_\_SET\_INTRA\_CHROMA\_DC\_FILTER\_444 1

#define ECF\_\_USE\_LUMA\_FILTER\_FOR\_CHROMA\_QUARTER\_SAMPLE\_INTERPOLATION 1

#define ECF\_\_ENABLE\_MDDT\_FOR\_444\_CHROMA 1

#define ECF\_\_USE\_TRANSFORM\_DEPTH\_FOR\_444\_CHROMA\_CBF\_CONTEXT\_SELECTION 0

#define ECF\_\_SIGNIFICANCE\_MAP\_CONTEXT\_CHANNEL\_SEPARATION 2

#define ECF\_\_LAST\_POSITION\_CONTEXT\_CHANNEL\_SEPARATION 2

#define ECF\_\_C1\_C2\_CONTEXT\_CHANNEL\_SEPARATION 2

#define ECF\_\_CBF\_CONTEXT\_CHANNEL\_SEPARATION 2

#define ECF\_\_EXTENDED\_CHROMA\_SIGNIFICANCE\_MAP\_CONTEXT 1

#define ECF\_\_EXTENDED\_CHROMA\_LAST\_POSITION\_CONTEXT 1

#define ECF\_\_EXTENDED\_CHROMA\_C1\_C2\_CONTEXT 1

#define ECF\_\_ADDITIONAL\_CHROMA\_QP\_MAPPING\_TABLES 1

# Experimental results

Common test condition for AHG7 is follows the BoG report of JCTVC-J0581.

Table 1 shows the summary of BD-rate for YUV444 sequences.

Table 1 Results of YUV444 chroma format.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10** | | | **Random Access HE10** | | | **Low delay B HE10** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Kimono | -5.4% | -1.4% | 3.4% | -3.8% | 5.7% | 6.7% | -3.4% | 3.6% | 7.8% |
| Parkscene | -6.2% | -1.3% | 0.6% | -5.0% | 3.7% | -1.2% | -4.7% | 2.6% | -0.1% |
| BirdsInCage | -3.4% | -4.2% | 5.7% | -3.8% | 14.1% | 10.0% | -2.7% | 9.1% | 4.8% |
| DucksAndLegs | -6.1% | -1.1% | 1.5% | -10.7% | 3.1% | -4.6% | -8.4% | 1.1% | -4.4% |
| Traffic | -5.0% | -1.1% | 3.9% | -5.4% | 5.0% | 9.3% | -4.8% | 6.0% | 12.5% |
| CrowdRun | -5.0% | -1.5% | -0.1% | -3.9% | 2.6% | 4.3% | -2.8% | 3.1% | 6.2% |
| OldTownCross | -1.0% | -4.2% | 3.0% | -1.9% | 4.9% | 11.9% | 0.5% | 1.9% | 14.6% |
| Seeking | -4.7% | -2.6% | -1.3% | -4.2% | 4.0% | 6.1% | -3.1% | 2.9% | 6.2% |
| **Overall** | -4.6% | -2.2% | 2.1% | -4.8% | 5.4% | 5.3% | -3.7% | 3.8% | 5.9% |
| Enc Time[%] | 132% | | | 105% | | | 104% | | |
| Dec Time[%] | 101% | | | 111% | | | 110% | | |

Due to the disable of chroma QP clipping, chroma BD-rate is significantly decreased. Unfortunately, current CTC of AHG7 has no RGB sequences. Because chroma QP clipping is effective for YUV chroma format, viewing test is required to show the effectiveness.

Following table shows that summary of BD-rate for additional results. This table can assess an influence of ECF\_\_ADDITIONAL\_CHROMA\_QP\_MAPPING\_TABLES. From this table, the proposed coding structure is effective for all intra case.

Table 2 Results of YUV444 chroma format with chroma clipping.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10** | | | **Random Access HE10** | | | **Low delay B HE10** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Kimono | -0.3% | -3.0% | -1.8% | 0.9% | -0.1% | -1.2% | 0.6% | -1.3% | -0.5% |
| Parkscene | -0.9% | -3.9% | -4.0% | 0.4% | -2.5% | -7.5% | -0.3% | -3.5% | -6.7% |
| BirdsInCage | 0.8% | -4.8% | 0.3% | 5.7% | 8.6% | 2.4% | 4.9% | 4.7% | -4.8% |
| DucksAndLegs | 0.7% | -3.2% | -0.5% | 4.7% | 1.6% | -4.6% | 2.4% | -0.4% | -7.8% |
| Traffic | -1.3% | -5.0% | -0.4% | 1.2% | -0.6% | 4.2% | 2.3% | 0.7% | 7.1% |
| CrowdRun | -1.7% | -5.1% | -3.9% | -0.6% | -4.8% | -3.2% | 0.0% | -3.9% | -1.2% |
| OldTownCross | 1.2% | -4.5% | 0.5% | 3.0% | 2.2% | 3.8% | 2.6% | 0.0% | 4.7% |
| Seeking | -1.0% | -5.2% | -4.0% | 0.2% | -2.3% | -1.5% | 0.5% | -2.3% | -0.8% |
| **Overall** | -0.3% | -4.3% | -1.7% | 1.9% | 0.3% | -1.0% | 1.6% | -0.7% | -1.2% |
| Enc Time[%] | 133% | | | 106% | | | 105% | | |
| Dec Time[%] | 103% | | | 112% | | | 112% | | |

Following table shows the summary of BD-rate for additional RGB444 sequences, which are obtained from VQEG web site. The proposed coding structure is effective for RGB444 sequences.

Table 3 Results of RGB444 chroma format.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10** | | | **Random Access HE10** | | | **Low delay B HE10** | | |
|  | G | B | R | G | B | R | G | B | R |
| CrowdRun | -9.3% | -4.9% | -4.6% | -14.4% | -4.1% | -3.1% | -13.3% | -1.2% | -0.1% |
| ParkJoy | -7.5% | -2.0% | -1.8% | -12.4% | 4.9% | 4.4% | -11.4% | 3.7% | 4.1% |
| DucksTakeOff | -8.2% | -2.0% | -0.2% | -18.7% | 5.3% | -1.3% | -19.3% | 1.7% | 0.7% |
| InToTree | -9.1% | -4.6% | -1.3% | -18.9% | 1.0% | 4.6% | -22.5% | 0.7% | 1.7% |
| OldTownCross | -7.4% | -2.5% | -2.0% | -11.0% | -0.2% | 0.4% | -10.7% | 0.9% | 2.1% |
| **Overall** | -8.3% | -3.2% | -2.0% | -15.1% | 1.4% | 1.0% | -15.4% | 1.1% | 1.7% |
| Enc Time[%] | 134% | | | 100% | | | 100% | | |
| Dec Time[%] | 102% | | | 103% | | | 101% | | |

Table 4 Results of RGB444 chroma format with chroma clipping.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE10** | | | **Random Access HE10** | | | **Low delay B HE10** | | |
|  | G | B | R | G | B | R | G | B | R |
| CrowdRun | -3.9% | -6.3% | -5.9% | -2.4% | -6.2% | -4.7% | -1.6% | -3.3% | -1.6% |
| ParkJoy | -1.3% | -3.9% | -3.4% | 0.8% | -0.5% | 1.3% | 1.2% | 0.0% | 0.6% |
| DucksTakeOff | -0.3% | -4.4% | -2.3% | 2.4% | -1.7% | 0.2% | 2.5% | -2.5% | 0.5% |
| InToTree | -0.4% | -5.7% | -2.7% | 6.5% | -1.9% | 3.5% | 4.5% | -1.6% | 2.3% |
| OldTownCross | -2.1% | -4.4% | -3.9% | -0.7% | -3.8% | -3.4% | -0.5% | -2.4% | -1.3% |
| **Overall** | -1.6% | -4.9% | -3.7% | 1.3% | -2.8% | -0.6% | 1.2% | -2.0% | 0.1% |
| Enc Time[%] | 138% | | | 106% | | | 105% | | |
| Dec Time[%] | 106% | | | 109% | | | 108% | | |

# Conclusion

This contribution proposed the consistent coding structure, the coding mode, and the tools for 444 chroma format. Experimental results showed that the proposed method achieved 4.6%/4.8%/3.7% BD-rate reduction for AI/RA/LDB-HE10 configuration for YUV 444 sequences. Chroma BD-rate degradation was caused by the disabled chroma QP clipping.

# References

1. D. Flynn, “BoG report: Extended chroma formats,” JCTVC-J0581, Stockholm, July 2012.

# Patent rights declaration(s)

**KDDI Corporation may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**